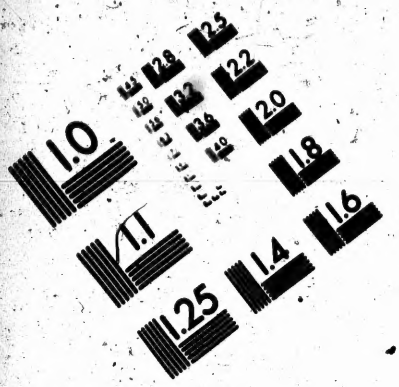


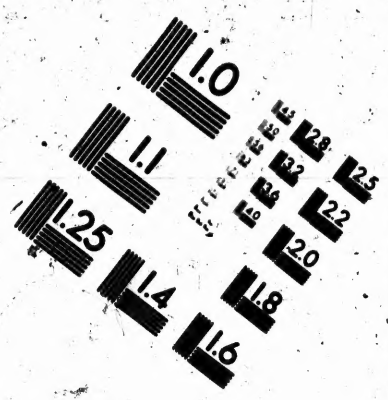
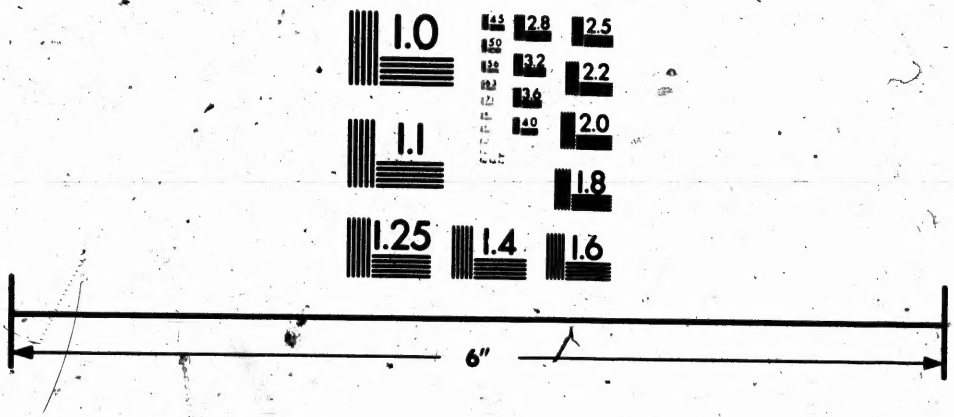
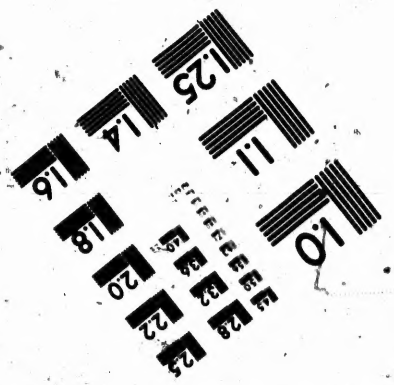


IMAGE EVALUATION
TEST TARGET (MT-3)





Photographic Sciences Corporation

23 WEST MAIN STREET
WEBSTER, N.Y. 14580
(716) 872-4503

Canadia

med here has been reproduced thanks
rosity of:

ibrary of the National
rchives of Canada

appearing here are the best quality
sidering the condition and legibility
al copy and in keeping with the
tract specifications.

ies in printed paper covers are filmed
ith the front cover and ending on
with a printed or illustrated impres-
back cover when appropriate. All
al copies are filmed beginning on the
th a printed or illustrated impres-
ding on the last page with a printed
l impression.

rded frame on each microfiche
the symbol ⟶ (meaning "CON-
r the symbol ▽ (meaning "END"),
pplies.

, charts, etc., may be filmed at
uction ratios. Those too large to be
ded in one exposure are filmed
the upper left hand corner, left to
to bottom, as many frames as
following diagrams illustrate the

L'exemplaire filmé fut reproduit grâce à la
générosité de:

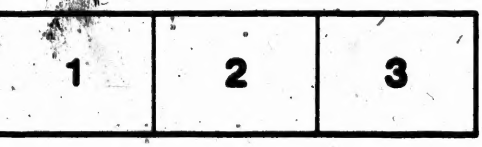
La bibliothèque des Archives
nationales du Canada

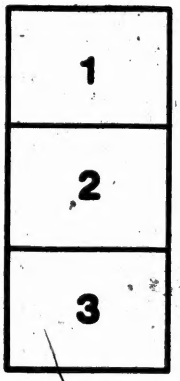
Les images suivantes ont été reproduites avec le
plus grand soin, compte tenu de la condition et
de la netteté de l'exemplaire filmé, et en
conformité avec les conditions du contrat de
filmage.

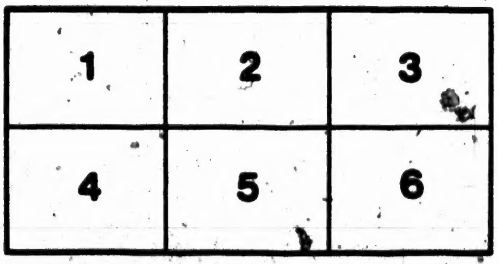
Les exemplaires originaux dont la couverture en
papier est imprimée sont filmés en commençant
par le premier plat et en terminant soit par la
dernière page qui comporte une empreinte
d'impression ou d'illustration, soit par le second
plat, selon le cas. Tous les autres exemplaires
originaux sont filmés en commençant par la
première page qui comporte une empreinte
d'impression ou d'illustration et en terminant par
la dernière page qui comporte une telle
empreinte.

Un des symboles suivants apparaîtra sur la
dernière image de chaque microfiche, selon le
cas: le symbole ⟶ signifie "A SUIVRE", le
symbole ▽ signifie "FIN".

Les cartes, planches, tableaux, etc., peuvent être
filmés à des taux de réduction différents.
Lorsque le document est trop grand pour être
reproduit en un seul cliché, il est filmé à partir
de l'angle supérieur gauche, de gauche à droite,
et de haut en bas, en prenant le nombre
d'images nécessaire. Les diagrammes suivants
illustrent la méthode.







(*All rights reserved.*)

ADVANCE PROOF—(*Subject to revision*).

This proof is sent to you for discussion only, and on the express understanding that it is not to be used for any other purpose whatever.—(*See Sec. 47 of the Constitution*).

Canadian Society of Civil Engineers.

INCORPORATED 1887.

TRANSACTIONS.

N.B.—This Society, as a body, does not hold itself responsible for the facts and opinions stated in any of its publications.

CEMENT MORTARS IN FREEZING WEATHER.

By M. J. Butler.

(*To be read Thursday, 12th April*, 1894.)

In considering what is best to be done when it is found necessary to carry on masonry work in freezing weather, if one searches the records of cement mortars found in the Proceedings of the various Engineering Societies, in the standard text-books used as a guide in the practice of the Profession, it will be found that the verdict is "don't do it." Failures in the past can be, no doubt, traceable to the effects of frost; nevertheless, success may be had by taking the necessary precautions.

In the late fall of 1892 the writer was compelled to construct about 600 cubic yards of masonry. After consulting all available sources for information and precedents, added the following clause to the specifications governing the works under his direction:—

"No masonry will be allowed to be laid in freezing weather unless so "ordered by the Engineer, in which case the following precautions "shall be taken:—The stones shall be warmed to remove any ice from "the surface, and the mortar mixed with brine made as follows:—Dis-"solve one pound of salt in 18 gallons of water when the temperature "is 32° F, and add one ounce of salt for every degree the temperature "is below 30° F, or enough salt, whatever the temperature to prevent "freezing."*

"The sand shall be heated sufficiently to thaw any frozen particles."

Cement and salt were furnished by the Railway Co.

In the actual carrying on of the work the steps taken were as follows:—

CEMENT.

A careful chemical analysis of the cement supplied showed the following composition:—

Lime	60.15
Silica	24.30
Alumin and Iron Oxid	10.78
Magnesia	1.18
Alkalies	1.60

FINENESS.

Seven per cent. residue was left on a standard sieve of 10,000 meshes to the square inch, 6 per cent. of which passed through a sieve of 22,000 meshes to the square inch.

*Quoted by J. J. R. Cross, Transactions American Society of Civil Engineers, Vol. XVI, p. 84, and there credited to the Royal Engineers; see also Baker's Treatise on Masonry Construction, page 543.

TENSILE STRENGTH.

Samples prepared with 25 per cent. of water, and pressed with the fingers into the moulds, when allowed one day in air and six days in water, broke with an average tensile strain of 350 lbs. to the square inch.

HOT TEST.

All the cement used was carefully submitted to the boiling test in thin pots on glass. None of the samples showed any cracks, and but one or two left the glass.

SAND.

The sand used was clean, rather coarse, sharp river sand, very nearly all silica.

Knowing from the success of the hot test that there was no danger to be feared from "blowing," all the brine was made with very hot water. The sand was kept as hot as possible. The stones were not heated, but care was taken to see that no ice was on them.

During the construction of the work the temperature varied between 39° above to 10° below zero F.

The whole work was carried forward to successful completion, and was and is satisfactory in every respect, no small credit being due to the contractor for the care and skill he showed in pushing on the work under very unfavourable conditions.

Another case where the masonry work was being built under the same specification, and where the contractor was obliged to furnish the salt, it was found that insufficient salt was used, and that as a consequence the outer portion of the mortar bed, about three inches back from the face, in the following spring was of about the consistency of leached ashes, which had to be raked out and replaced with fresh Portland cement mortar; the inner part of the mortar bed was set hard and solid—doubtless the outer portion froze solid, the inner being protected from the severe frost by the overlying stone and at the edge by the parts destroyed.

Another case where natural cement was used in stuccoing a building, having been put on in a coat about one inch thick, failed entirely. In fact, natural cements will not stand frost in the sense herein implied.

During the construction of the Kansas City Bridge,* "the beton, consisting of eight parts limestone, was broken to pass through a three-inch ring, two of sand and three of cement. It is an interesting fact that both masonry and beton were laid in the above works in the severe winter months by the use of hot sand and hot water. At the Quincy Bridge, during the coldest weather, each stone was held over a brazier of charcoal to draw out the frost. The mortar thus used was found the following spring to be as hard and perfect as any on the work."

During the construction of the Chignecto Ship Railway in Nova Scotia, some experiments were tried, which seemed to show a reduction in strength in the samples submitted to the testing machine.† Doubtless the effect of frost on small samples, from the fact that it will penetrate the whole mass, is more serious than in actual works where the effects will be confined to the outer edges of the mortar beds.

In the construction of the works of a lock at the St. Mary's Falls' Canal ‡ in 1877, it was found that Portland cement mortars satisfactorily withstood the effects of frost, but that natural cement mortars were disintegrated to the depth of 3 or 4 inches; in the same locality a Portland cement concrete which froze solid proved satisfactory.

* Manual for Railroad Engineers, by Geo. L. Vose.
† Proceedings Inst. C. E., Vol. CVII.
‡ Transac. Amer. Soc. C.E., Vol. XVI, pp. 79 et seq.

The sample tests with various quantities of salt used in the above mentioned work go to show that the strength of the mortar increased with the quantity of salt used.

The Austrian Society of Civil Engineers & Architects (*) have recently investigated the question of masonry construction in freezing weather.

"During a temperature below 26° F, 14 brick walls were built, each 3 "ft. 4 ins. long, 6 ft. 8 in. high, and 10 in. thick. The following mor- "tars were used:

"(1) Common fat lime mortar, (2) Roman cement mortar, (3) Port- "land cement mortar, (4) 1 of Portland cement to 2 of lime, (5) "cement and slag mortar. All these mortars were tried over with cold "water and once with warm water (77° F), and some of them were tried "with a 7 per cent. cold salt solution. Two walls were also built with "a frost-proof mortar,—Patent Hausleitner.

"The first three mortars were also tested on nine rubble masonry "walls, the same length and height as the brick walls, and 15 ins. thick. "The water was used ith the same variations was above. Half of each "wall was covered with boards, and the covered half showed in each "case somewhat better results.

"After three months the walls were examined; wherever lime had been used, either alone or with cement, the result was a failure.

"The use of Roman cement gave different results according as it "was used on brick or stone.

"Portland cement with cold salt solution and frost-proof cement "'Patent Hausleitner' were the only mortars which gave perfect satis- "faction, and these were in good order when used as exterior finish."

Inasmuch as we in Canada are debarred from construction about four months in each year, if it be unsafe to build masonry work, it is considered important to show that with proper materials properly handled there need be no fear to use Portland cement mortar on account of cold weather; and in the hope that the resulting discussion will bring out many precedents the foregoing notes have been prepared.

(*) Engineering News, 1894, p. 253, Vol. XXXI.